Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

Gene Flow Analysis for Environmental Safety in the Tropics

Research Project supported by BMZ of Germany

Gene Flow Analysis and Biodiversity Implications in the Wild/ Weed/ Crop complex of common bean

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CIAT, Palmira, 15th June 2007

Outline

1. Introduction: why common bean, why Costa Rica ?

2. Distribution of target materials in the Central Valley

3. Evidence of gene flow between cultivated and wild forms in Costa Rica

4. Evidence of gene flow between cultivated forms on station and *in situ*

5. Evidence of gene flow across the geographic range

6. Evidence of gene flow involving other species of the phylum

7. Conclusions

Why the common bean model ?

Transgenic common bean: tolerance to herbicide Glufosinate Ammonium

Aragão et al. 2002

Transgenic common bean: resistance to Bean Golden Mosaic virus

Aragão et al. 1998

Transgenic common bean: storage protein with higher methionine

Aragão et al. 1999

any genetically modified bean material (alien gene pool) :

responsible agriculture !

Reports about natural outcrossing in common bean

location	%	source
Mexico, México, Chapingo	1.3-7.4	Miranda Colín 1971
Mexico, Puebla, Tecamachalco	4.5	Crispín 1960
*Mexico, Puebla, sierra Norte	20-55	Gepts et al. 2000
Puerto Rico, Mayagüez	0.5-39.3	Brunner & Beaver 1989
*Colombia, Valle, Cerrito	1.5-8.7	Triana et al. 1993
USA, California, Irvine	1.9-3.7	Ibarra-Peréz et al. 1996
USA, California, Irvine	11.5-66.8	Wells et al. 1988
USA, California, Berkeley	0.73	Mackie & Smith 1935
Brazil, Paraná, Maringá	0.004- 2.25	Regina Royer et al. 2000
Brazil, Rio Grande do Sul, Pelotas	5.0	Silveira et al. 2001
Ethiopia, Sidamo, Awassa	4.8	Stoetzer 1984
Spain, Asturias, Villaviciosa	0.74	Ferreira et al. 2000

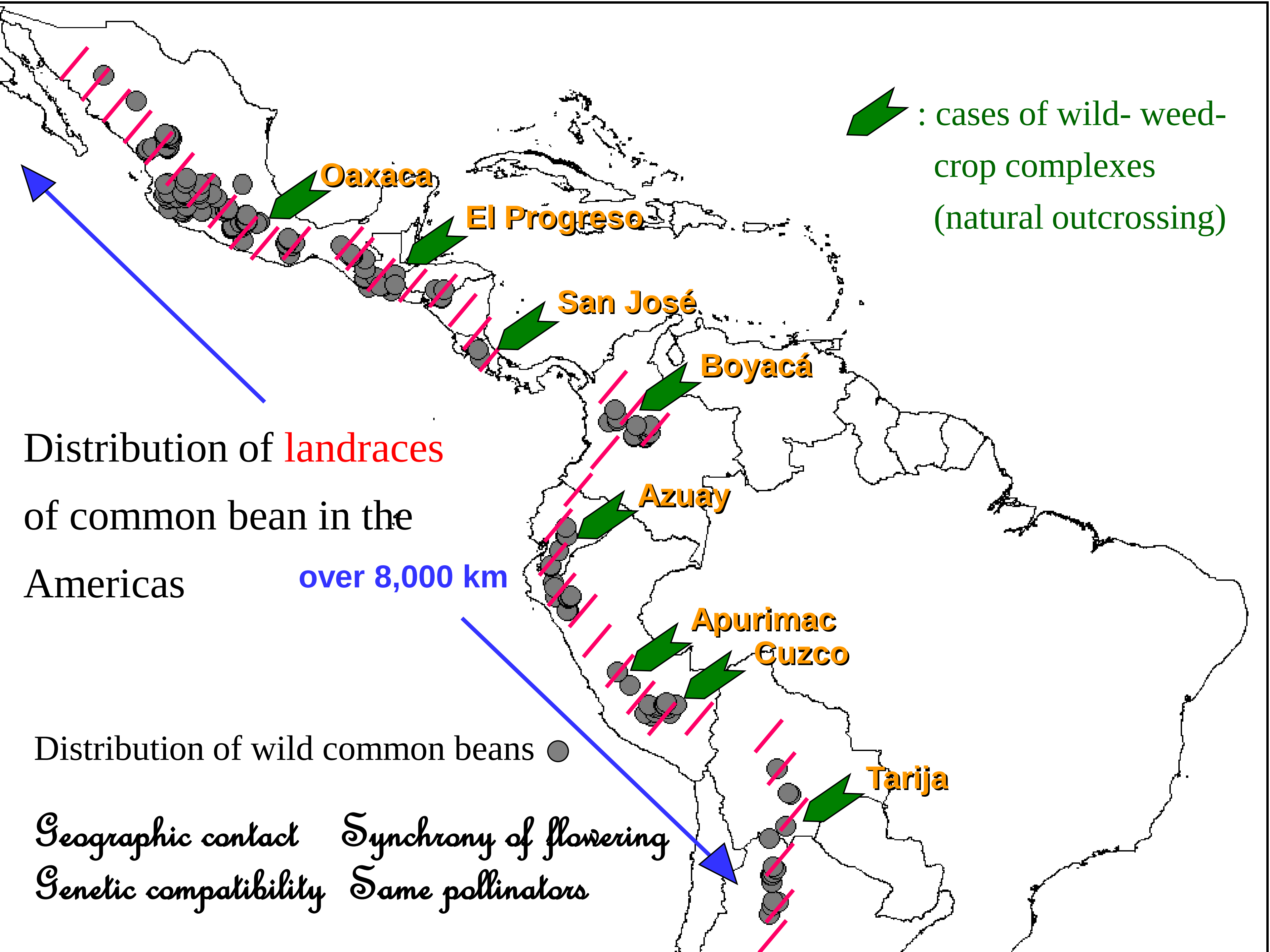
* = involving wild forms

Segregation obtained from a single bean population (DGD-2259) found in Apurimac, Peru, in 1987.

Example of complex gene flow involving wild forms and landraces

with phaseolin types and 100 seed weight

source: Beebe et al. 1997

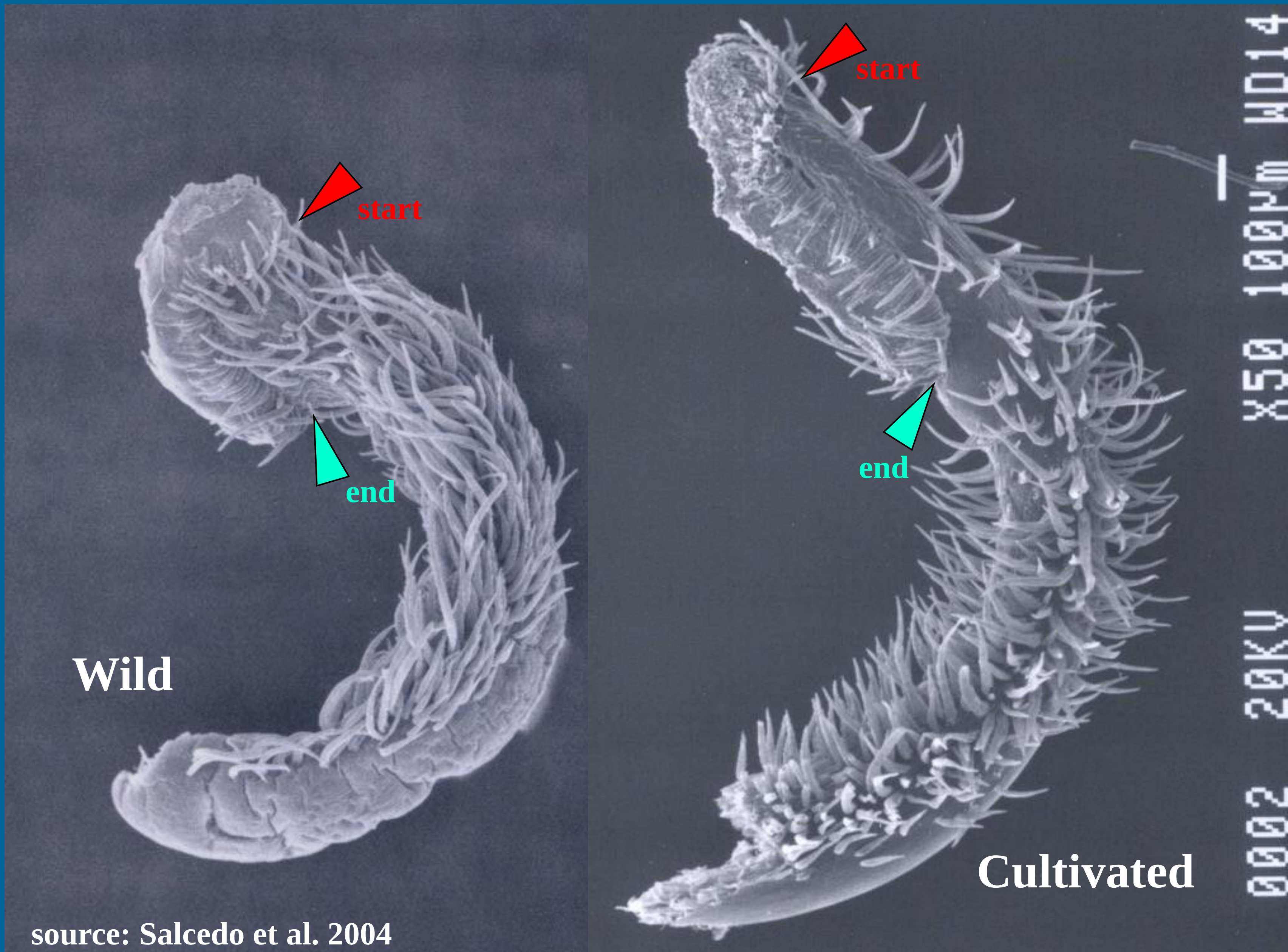

: cases of wild- weed- crop complexes (natural outcrossing)
Oaxaca
El Progreso
San José
Boyacá
Azuay
Apurimac
Cuzco
Tarija
Distribution of landraces of common bean in the Americas
over 8,000 km
Distribution of wild common beans
Geographic contact
Synchrony of flowering
Genetic compatibility
Same pollinators

Wild-weed-crop complexes in beans in the Americas

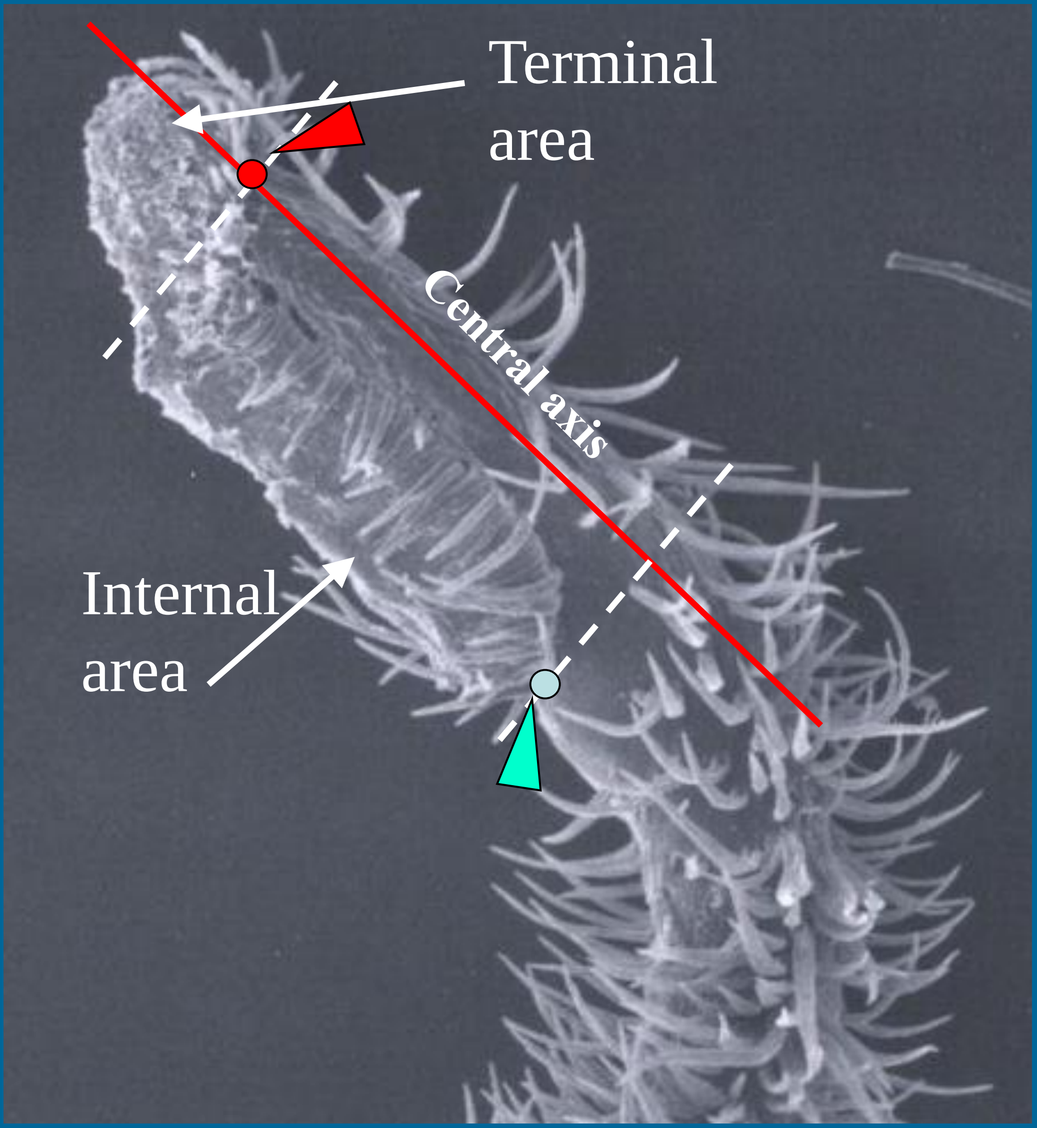
(natural outcrossing)

location	source
Mexico, Oaxaca, Sto. Domingo Albarradas	Acosta et al. 1994
Guatemala, Progreso, Agustín Acasaguastlán	Debouck 1988
Guatemala, Quetzaltenango, Zúnil	Debouck 1995
Costa Rica, San José, Aserrí	Debouck et al. 1989a
Colombia, Cundinamarca, Choachí	Beebe et al. 1997
Ecuador, Azuay, Girón	Debouck et al. 1989b
Peru, Junín, Huacapistana	Debouck et al. 1989c
Bolivia, Tarija, Tabladita	Debouck 1994

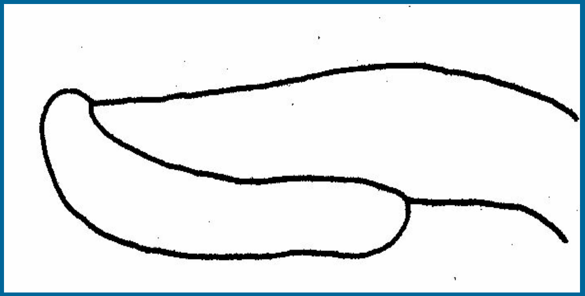
Morphology of style and stigma in common bean



Method



Determination of the internal and terminal areas of stigma



Generation of diagrams for wild and cultivated (landrace and modern)

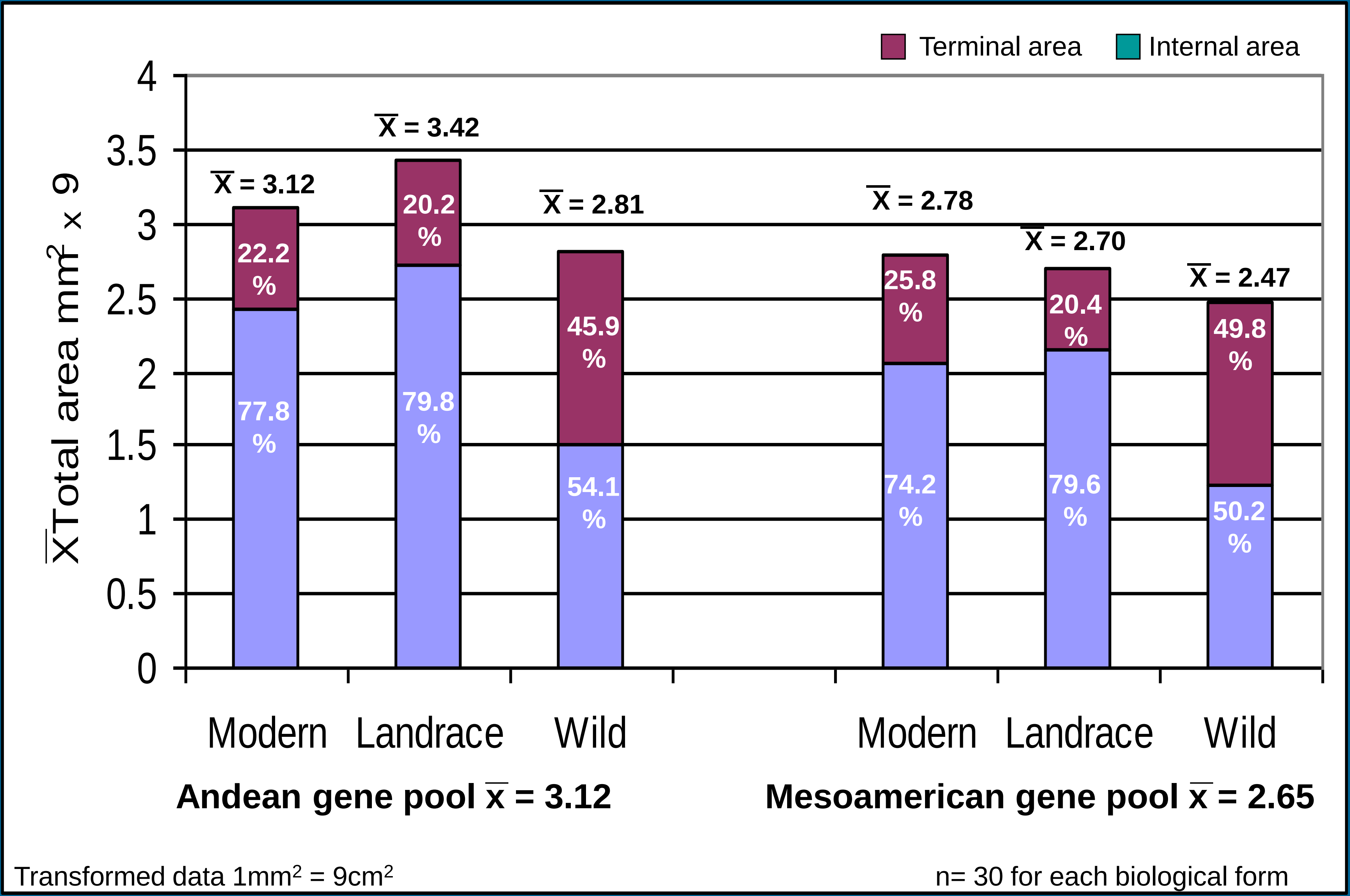
a. Total area

b. Terminal area

c. Internal area

- All diagrams were processed with the software WinRhizo.ProV.2002c for analysis of data areas

Ratio between internal and terminal areas



source: Salcedo et al. 2004

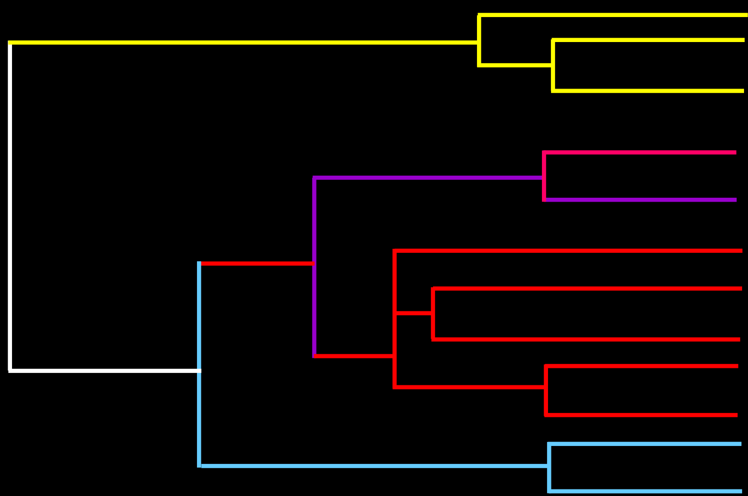
vulgaris as member of the *Phaseoli* still has a terminal stigma !

adapted from Delgado et al. 1999

Chacón et al. 2007

adapted from Freytag & Debouck 2002

(2x= 2n = 22)



Section *Acutifolii*

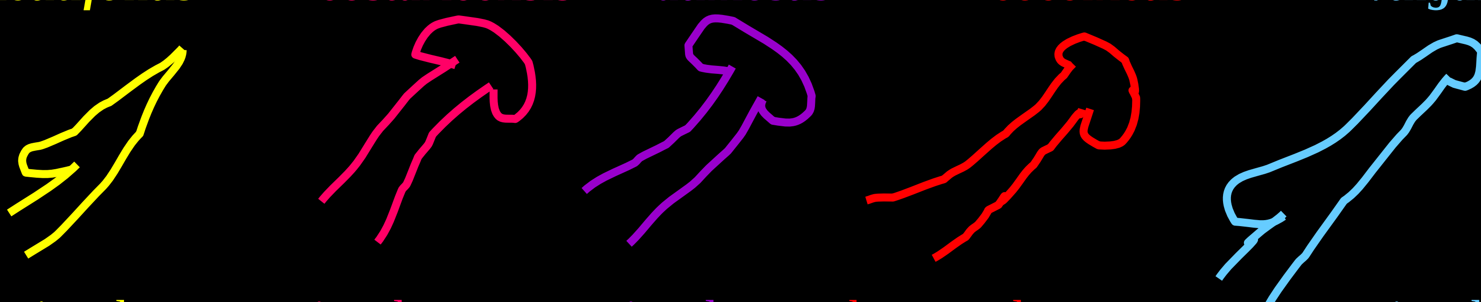
Section *Phaseoli*

Section *Coccinei*

5-7/ 78 !

Section *Phaseoli*

acutifolius ***costaricensis*** ***dumosus*** ***coccineus*** ***vulgaris***



epigeal epigeal epigeal hypogeal epigeal

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Costa Rica:

Aserrí, en San José

Piedra de Aserrí

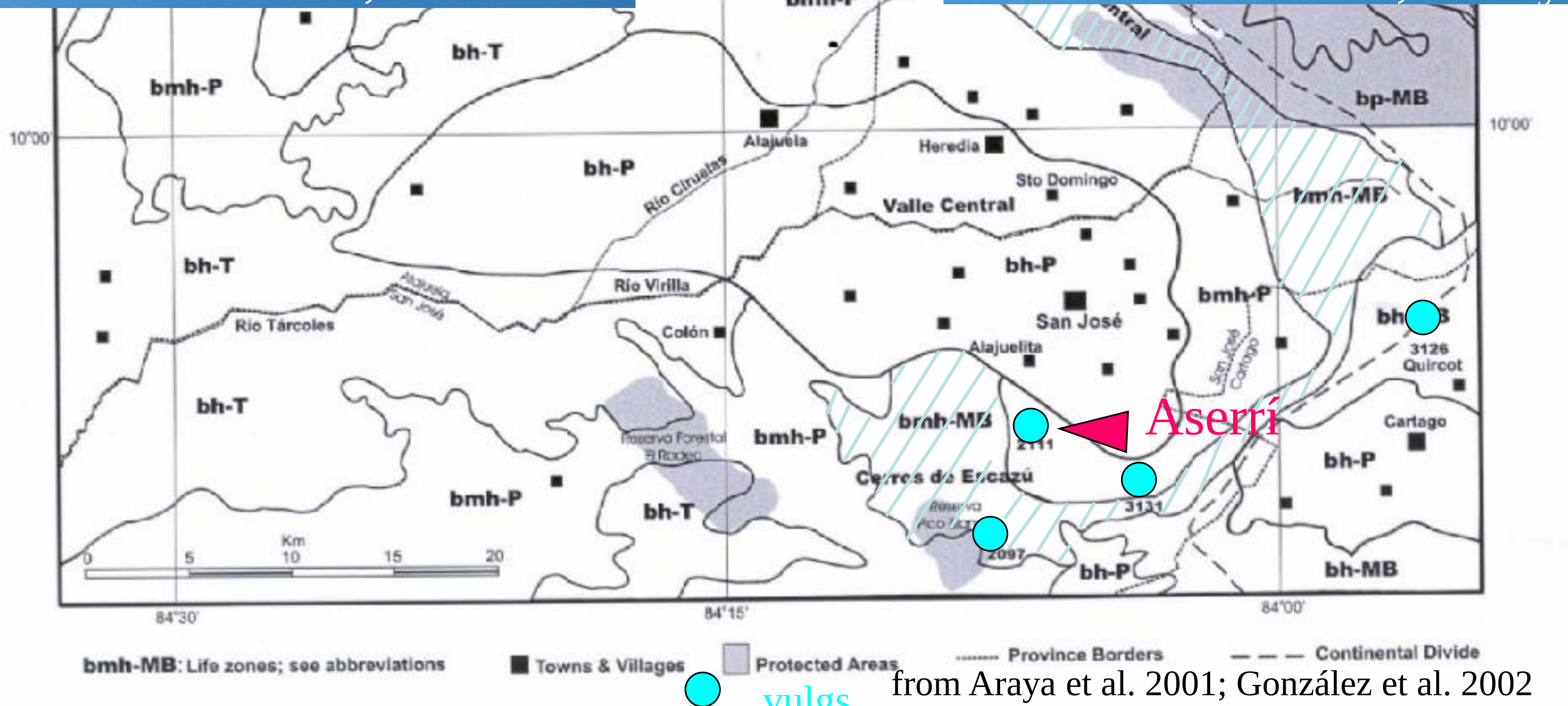
Phaseolus vulgaris L.

wild type

2111

11 January 1987

Standley 1937 !



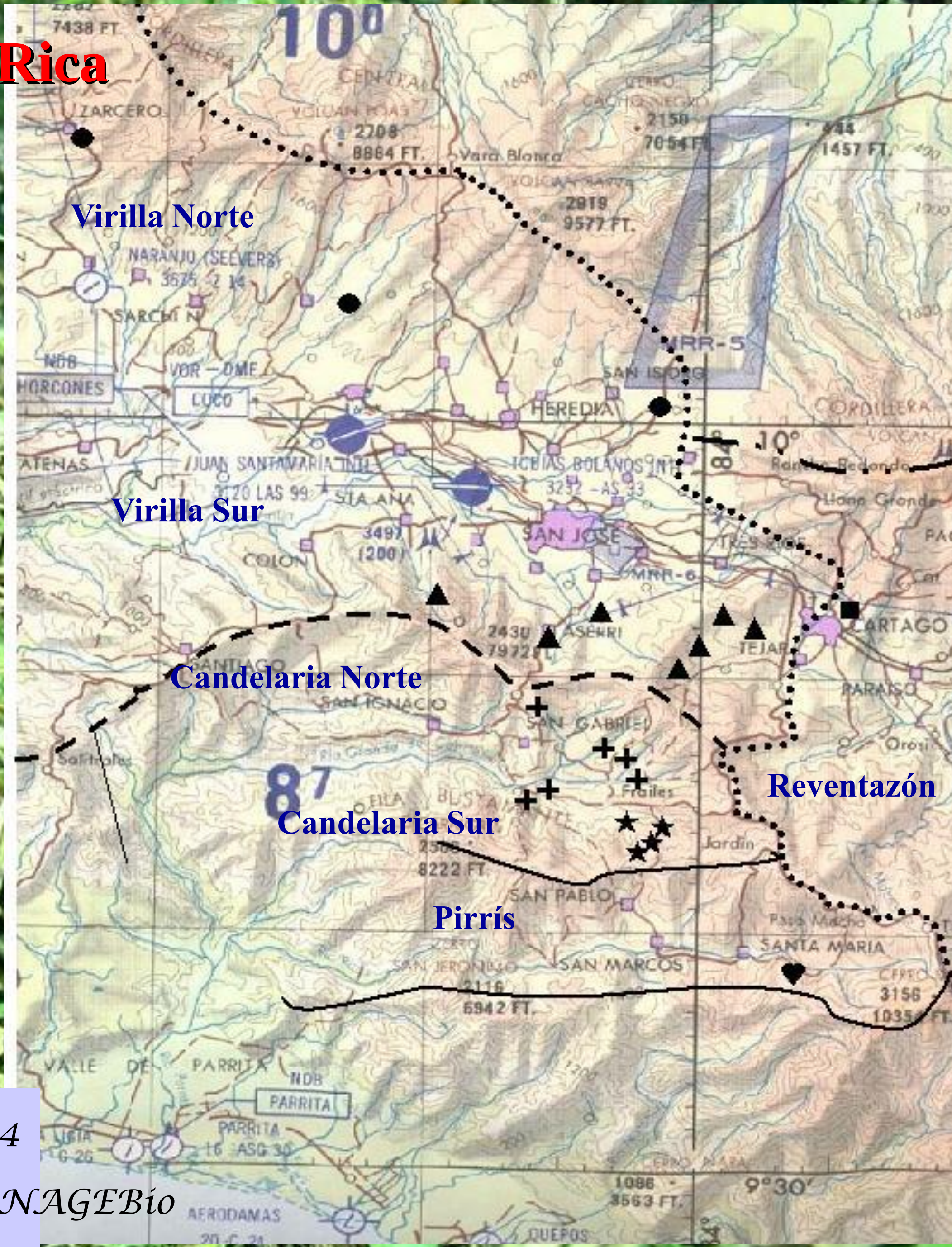
from Araya et al. 2001; González et al. 2002

Wild common bean in Costa Rica

22 populations in
4 watersheds

location

conservation status



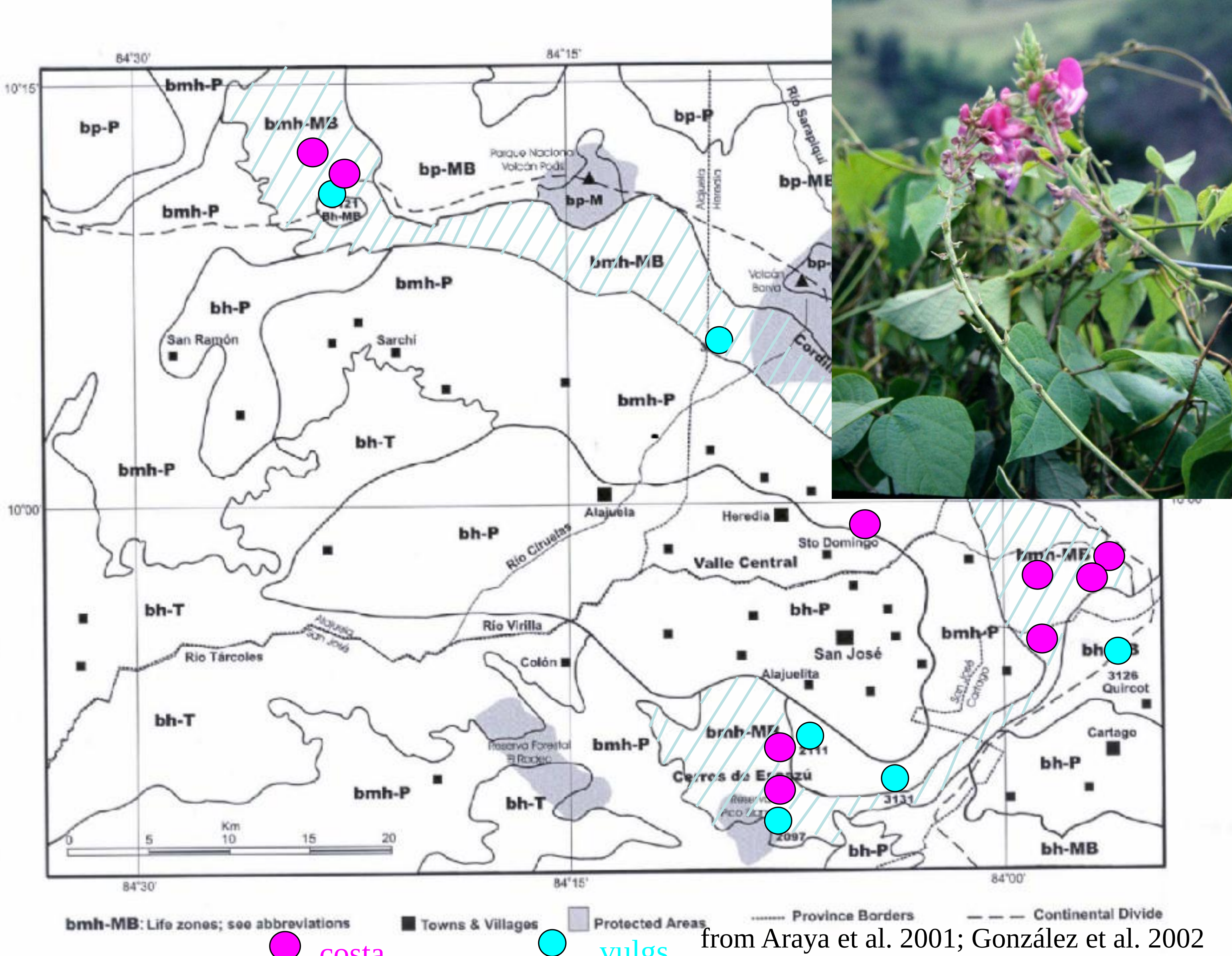
Explorations of 1987, 1998, 2002, 2003, 2004

in cooperation with U. Costa Rica and CONAGEBio

native
introduced
novel

Progress of knowledge on *Phaseolus* species in Costa Rica

1937: 5	1985: 7	1989: 10	2002: 11	2006: 13
		acutifolius	*acutifolius*	*acutifolius* †?
				angucianae †?
coccineus	*coccineus*	*coccineus*	*coccineus*	*coccineus*
		costaricensis	*costaricensis*	*costaricensis*
	dumosus	*dumosus*	*dumosus*	*dumosus*
				hygrophilus
leptostachyus	*leptostachyus*	*leptostachyus*	*leptostachyus*	*leptostachyus*
lunatus	*lunatus*	*lunatus*	*lunatus*	*lunatus*
oligospermus	*oligospermus*	*oligospermus*	*oligospermus*	*oligospermus*
			talamancensis	*talamancensis*
	tuerckheimii	*tuerckheimii*	*tuerckheimii*	*tuerckheimii*
		vulgaris	*vulgaris*	*vulgaris*
xanthotrichus	*xanthotrichus*	*xanthotrichus*	*xanthotrichus*	*xanthotrichus*
Standley	**Delgado**	**Debouck et al.**	**Freytag & Debouck**	**Araya & Debouck**



from Araya et al. 2001; González et al. 2002

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Conclusions

1. Populations of wild forms, compatible wild species, and hybrid swarms mapped for Costa Rica :

possible (lag with GIS; variation year-to-year)

areas for conservation/ for agricultural production defined

2. Hybrid swarms identified by morpho-agronomic variation confirmed by molecular markers :

methodology established

problem of quantification ; no mastering of sampling in open vegetation !?

3. Direction of gene flow predominantly from wild into cultivated; other direction present, in cases predominant :

grouped flowering = direct effect of domestication

why the change ?

4. Gene flow is very limited among improved varieties, less limited among landraces :

cleistogamy = indirect effect of domestication !?

genetic linkage still unknown

Conclusions (cont.)

5. On station, gene flow seems related to temperature and insect activity

   heat stress - unpredictable - would favour outcrossing

   active pollinators ***versus*** nectar robbers !

6. Hybrid swarms are repeatedly found across the range, where forms are in contact

   likely mechanism by which races were formed in an autogamous crop !

   contact is becoming elusive !

7. Other species of the phylum might be involved but with limited consequence :

   these wild legumes are ‘good’ species !

   limited biological, evolutionary significance, but . . . if humans find advantage !

8. Long-term persistence is conditioned to direct/ indirect human activities

   little use of hybrid swarms by farmers; domestication is past !?

   today management of rural landscape does not favour weedy forms

Thank you !

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